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13. ABSTRACT *(Maximum 200 words)*

Our goal to improve the effectiveness of atom cooling by using radio-frequency evaporation was met early in the grant period, and we obtained temperatures and densities close to those needed for Bose-Einstein condensation. Consequently, we deferred our work on high resolution optical spectroscopy of hydrogen while we pursued BEC. We obtained BEC last June, using new spectroscopic methods to identify the onset of the transition and to characterize the condensate. Briefly, we found that the mean field interaction at high densities measurably shifts the 1S-2S spectral line, and that the frequency shift can be used to measure the density *in situ*. From the point of creating an optical frequency standard, it is essential to know this frequency shift, since the density must be kept sufficiently low that the shift is not a source of error.

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Optical Frequency Standard in Trapped Atomic Hydrogen
April 1, 1998- March 31, 1999
Daniel Kleppner, Principal Investigator

ANNUAL TECHNICAL REPORT

Our goal to improve the effectiveness of atom cooling by using radio-frequency evaporation was met early in the grant period, and we obtained temperatures and densities close to those needed for Bose-Einstein condensation. Consequently, we deferred our work on high resolution optical spectroscopy of hydrogen while we pursued BEC. We obtained BEC last June, using new spectroscopic methods to identify the onset of the transition and to characterize the condensate. Briefly, we found that the mean field interaction at high densities measurably shifts the 1S-2S spectral line, and that the frequency shift can be used to measure the density *in situ.* From the point of creating an optical frequency standard, it is essential to know this frequency shift, since the density must be kept sufficiently low that the shift is not a source of error.

We have resumed work on high precision spectroscopy by designing a new laser stabilization scheme. Under an ONR DURIP award we have obtained funding for an up to date laser system, which we expect to order shortly.

We have started informal discussions with Professor T. W. Haensch on the possibility of a collaboration to apply new optical frequency measurement techniques he has developed to measure the 1S-2S frequency to ultra high precision, or alternatively to establish the transition as an optical frequency measurement.

The following publications have been issued during the grant period.

Cold Collision Frequency Shift of the 1S-2S Transition in Hydrogen, Thomas C. Killian, Dale G. Fried, Lorenz Willmann, David Landhuis, Stephen C. Moss, Thomas J. Greytak and Daniel Kleppner, Phys. Rev. Lett. **81**, 3807 (1998).

Bose-Einstein Condensation of Atomic Hydrogen, Dale G. Fried, Thomas C. Killian, Lorenz Willmann, David Landhuis, Stephen C. Moss, Daniel Kleppner and Thomas J. Greytak, Phys. Rev. Lett. **81**, 3811 (1998).

Bose-Einstein Condensation of Atomic Hydrogen, Daniel Kleppner, Thomas J. Greytak, Thomas C. Killian, Dale G. Fried, Lorenz Willmann, David Landhuis and Stephen C. Moss, Proceedings of the International School of Physics "Enrico Fermi", Course 140, 1998.

The following paper has been accepted for publication: Two-photon Doppler-Free Spectroscopy of Trapped Atoms, Claudio L. Cesar and Daniel Kleppner, Phys. Rev. A 6/99.

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